Prescale to 1GHz

Nick Wheeler describes a low-cost prescaler designed to extend the useful range of a frequency counter to just over 1GHz.

Until recently, digital frequency meters with gigahertz capability were confined to costly laboratory models, the more affordable types generally extending up to, typically, 200MHz. Some eight years ago, and possibly even earlier, it was possible to obtain gigahertz prescalers based on emitter-coupled-logic to extend the range of these inexpensive instruments – many of which must still be in use.

While ecl-based gigahertz prescalers have been around for years they have either been expensive or only obtainable in production quantities. One of the earliest was the Philips *SAB456*, used in a tv tuner for digital frequency control, but this was discontinued in eight-pin DIL form some years ago.

More recently, the developing portable phone market has caused several manufacturers, including Philips, to produce useful low-cost parts. I used the quadruple-modulus *SA701*, which is intended for 64/65 and 128/129 division. This device is is obtainable in small quantities from RS and Macro. Note that its part number for the DIL version has an 'N' suffix.

Table 1. On the SA701 prescaler, logic levels on two pins determine the division ratio.

Divisor	SW	MC
128	Low	High
129	Low	Low
64	High	High
65	High	Low

Applying the GHz prescaler

With the exception of the Plessey *SP8680*, which is a 650MHz part, ecl prescalers have ecl output levels and limited output drive capability into capacitive loads. **Figure 1** shows how these problems are overcome.

Emitter follower Tr_1 imposes negligible load on the prescaler and the diode clamp ensures that there is a big enough positive excursion at the base of Tr_2 to bottom it. Collector swing of Tr_2 is enough to drive the high-speed c-mos divider chain which follows. Pins 3 (SW) and 6 (MC) determine the division ratio, as in the **Table 1**.

For this application, the division ratio needed is 64, so both SW and MC are high. To avoid having to use a calculator to determine

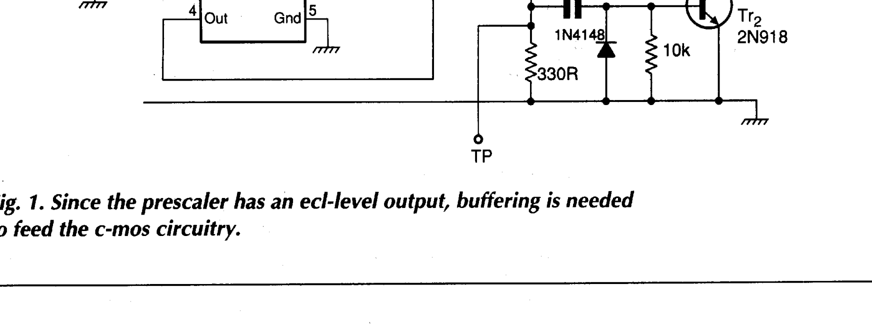

Fig. 1. Since the prescaler has an ecl-level output, buffering is needed to feed the c-mos circuitry.

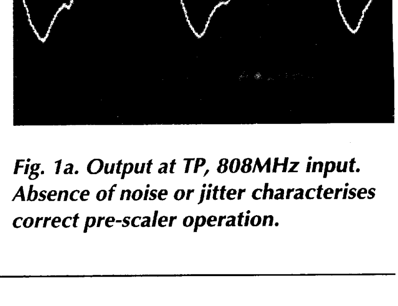

Fig. 1a. Output at TP, 808MHz input. Absence of noise or jitter characterises correct pre-scaler operation.

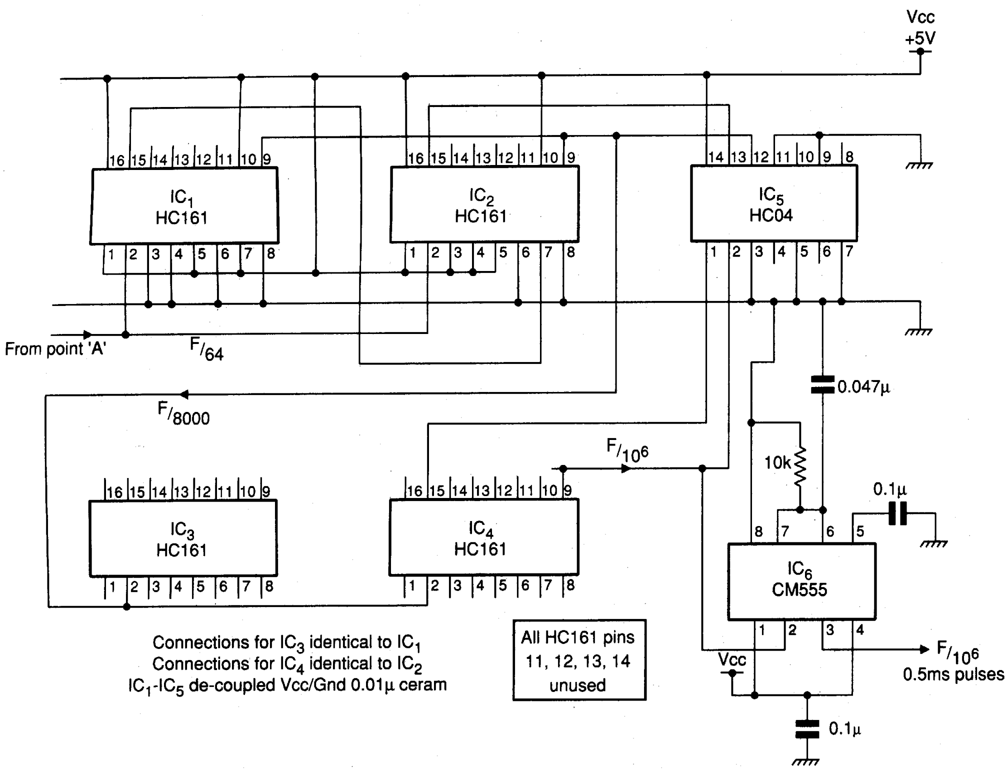

Fig. 2. Using this configuration to divide by 125 avoids glitch problems. Narrow pulses output by the divider chain could cause erratic readings so a pulse-stretching 555 is added.

the frequency being measured, the overall division ratio must be a multiple of ten. There is a way round this but it usually involves having a special crystal made for your frequency counter. Suppose the counter has provision for an external frequency standard. This will certainly be a multiple of 1MHz. However, if an external source which is an appropriate multiple of 976.5625kHz is applied, then a binary divider chain of ten stages will give a readout of kilohertz for gigahertz – which is manageable.

Fortunately, division by 2^6 (64), followed by 5^6 (15625) equates to division by 10^6. This is done by dividing twice by 125.

Dividing by 125

Figure 2 shows the divider, taken from ref. 1. The timing diagram for this rather unusual ratio is complicated. It is fortunate that this ratio is not one of those which suffer from incurable glitches. Note that the quirky timing of this circuit calls for 116 to be preloaded. Follow the circuit diagram and you will arrive at the desired result.

The circuit works without problems from 20MHz down to 1MHz, representing an input signal frequency range of 1.28GHz down to 64MHz. Division in two cascaded blocks of 125 is essential as there is a possible glitch problem if three or more *HC161*s are cascaded. Texas Instruments' manual explains this.

Unlike binary division, which yields successive outputs of close to unity mark-space ratio, each of the two cascaded divide-by-125 stages yields a signal of 1:124 mark-space ratio. Thus an input signal of 1GHz produces an output of 1kHz, but with a pulse width of 8µs. Some inexpensive frequency counters respond erratically to waveforms of this sort, so the c-mos *555* monostable is included to stretch the pulses to around 0.5ms.

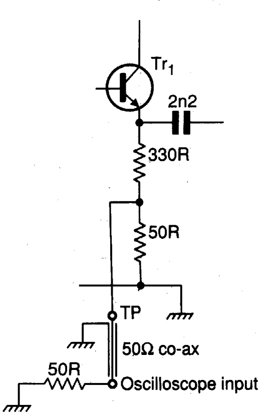

Fig. 3. To check for correct operation of the prescaler, care must be taken with loading and termination.

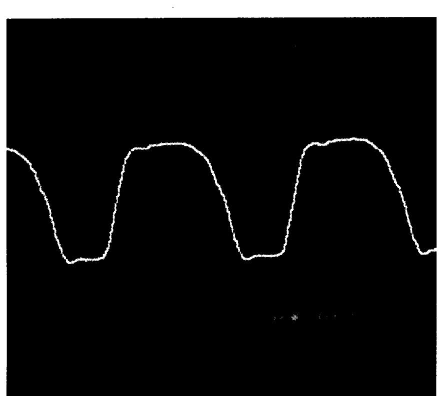

Fig. 3a. Waveform at TP viewed in properly terminated system. Absence of noise and jitter characterises correct prescaler operation. Test frequency 808MHz.

Implementation problems

It appears to be a characteristic of ecl prescalers that if no input, or too small an input, is connected, oscillation occurs around the upper frequency limit of the device. Such oscillation can be detected at the emitter of Tr_1 which, fed to a suitable rf connector, forms the output. The oscillatory mode has random time-jitter and is quite different in appearance from the waveform observable when division is occurring properly, **Fig. 3**.

This test point has another important function. Because the signal frequency is divided by 10^6 long gate times are required to make accurate frequency measurements. At 1GHz, and with 100 seconds of gate time, the display is only to five decimal places or 100kHz. Often this will be unimportant. Where greater accuracy or a quicker response is needed, the divide-by-64 point gives results at once and to the full accuracy of the frequency meter. But you will need a calculator to work out the real frequency being read.

Best results are obtained at the upper frequency end if the prescaler is mounted on PTFE based pcb, but much the same effect can be achieved by preceding the prescaler with a monolithic microwave IC such as the *MAR 6*.

Measurements at gigahertz frequencies can only be conducted remotely, and in this case remotely means at distances of more than a few cm, via properly matched transmission lines. You can seen from Fig. 1 that this is a 50Ω system.

For remote measurements, where the imposition of a 50Ω load is unacceptable, an approach on the lines of ref. 2 is appropriate. This type of circuitry still has gain well beyond 1GHz, though it has fallen off a lot compared with the flat frequency performance up to 130MHz. ■

References

1. Lancaster, D., Sam's TTL Cookbook, 1988.
2. Wheeler, N., 130MHz probe, *EW+WW* Aug 1995.